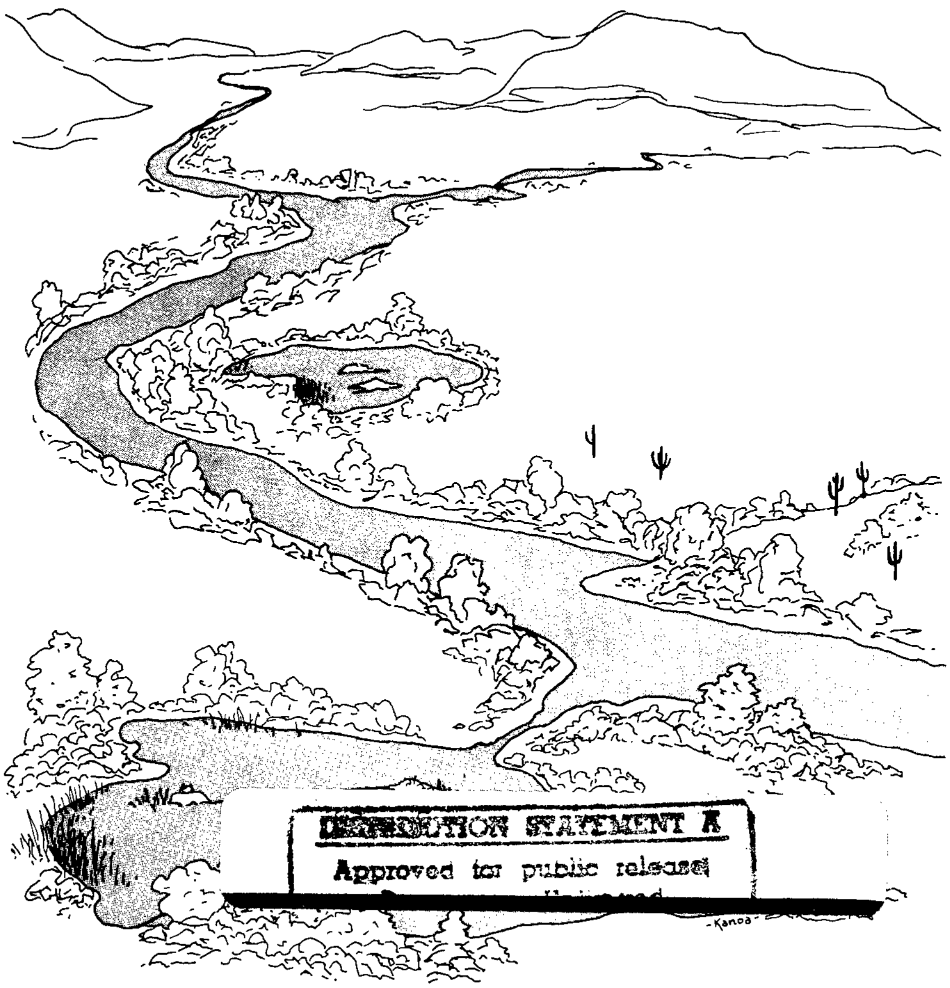
Sand and Gravel Pits as Fish and Wildlife Habitat in the Southwest



UNITED STATES DEPARTMENT OF THE INTERIOR
Fish and Wildlife Service / *Resource Publication* 171

Resource Publication

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Library of Congress Cataloging-in-Publication Data

Matter, William J.
Sand and gravel pits as fish and wildlife habitat in the Southwest.

(Resource publication ; 171)
Supt. of Docs. no. : I 49.66:171
Bibliography: p.
1. Sand and gravel industry—Environmental aspects—Southwestern States. 2. Wildlife habitat improvement—Southwestern States. 3. Reclamation of land—Southwestern States. 4. Riparian ecology—Southwestern States. I. Mannan, R. William. II. Title. III. Series: Resource publication (U.S. Fish and Wildlife Service) ; 171.
S914.A3 no. 171 333.95′4′0973 s [639.9′2] 88-600076
[QH545.537]

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By William J. Matter
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UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
Resource Publication 171
Washington, D.C. • 1988

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by

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Abstract

The mining of sand and gravel deposits in the floodplains of rivers can disturb valuable riparian habitat in the arid Southwest. Disturbed land can be reclaimed to provide fish and wildlife habitat if water is present. The depth, shoreline shape and slope, area, location and number of sand and gravel pits, and the plant species that revegetate disturbed areas can be managed to influence subsequent colonization by animals. Native species of plants generally are preferable to exotics when revegetating disturbed areas, even if native species require special treatments to become established. Streamside pits can be made into backwater habitats, but they must be protected from flooding and sedimentation. Monitoring of critical habitat features and plant and animal species is necessary to document the effectiveness of reclamation efforts, and to ensure that habitat, once established, is not lost.

Sand and gravel are essential to nearly all construction and development activities (Schellie and Rogier 1963). The area disturbed by a single mining operation generally is small (e.g., 5–40 ha), but the combined influence nationwide is substantial. Nearly 400,000 ha were affected by sand and gravel mining in the United States in a recent 40-year period (Swanson 1982). Extraction operations generally are close to where the sand and gravel are used because these materials, though relatively inexpensive, are expensive to transport (Johnson 1966); most operations also are long-term (30+ years; Blauch 1978). Sand and gravel pits are, therefore, common and highly visible in many urban settings and in rural areas, primarily along roads.

Awareness that gravel pits might be valuable habitat for some species of wildlife began in Great Britain in 1931 when several great crested grebes (*Podiceps cristatus*) were found occupying flooded pits (Harrison and Hollom 1932). This discovery was significant because the great crested grebe had been relatively scarce in Great Britain because of past exploitation by plume hunters. A more recent survey indicated that about 22% of all great crested grebes found in Great Britain were associated with gravel pits (Prestt and Mills 1966). Another species, the little ringed plover (*Charadrius dubius*), expanded its breeding range in Great Britain in the mid-1900's by using flood pits as nest sites (Tydeman 1982). Surveys of all species of birds at flooded gravel pits in Great Britain indicated that these man-made wetlands tended to increase bird species richness throughout the year (Keywood and Melluish 1953).

The value of flooded gravel pits as habitat for wildlife in the early and mid-1900's was the result of natural successional processes following abandonment (Milne 1974). Procedures for reclaiming lands disturbed by sand and gravel mining, both in the United States and Great Britain, were developed primarily after 1960 (e.g., Schellie and Rogier 1963; Bauer 1965; Johnson 1966; Baxter 1969; Pickels 1970). These procedures, however, rarely addressed the habitat requirements of animals associated with wetlands. Recent interest in reclaiming mined lands specifically for fish and wildlife species has been stimulated by the conversion of some flooded pits into valuable wetland and riparian habitat (Svedarsky and Crawford 1982).

We outline management practices and design considerations that could be used to create or enhance wetland habitat in flooded sand and gravel pits in or near riverine systems in the southwestern United States. In many instances, these practices also apply to the management of flooded quarries and borrow pits as wetlands (see Blauch 1978 for definitions of gravel pits, quarries, and borrow pits). Management practices for dry pits are primarily restricted to restoration of the vegetation that existed before mining took place and are not addressed.

Sand and Gravel Pits as Wetlands in the Southwest

Sand and gravel deposits commonly occur in the floodplains of rivers (Swanson 1982). Extraction of these materials must then frequently occur in riparian zones. Riparian zones are known to be important habitat for many vertebrate species, especially in the Southwest and other arid regions of the world (Johnson and Jones 1977; Johnson et al. 1985). These zones frequently support a greater number of species and individual plants and animals than adjacent upland systems (Carothers et al. 1974; Davis 1977). Furthermore, riparian zones generally occupy a much smaller percentage of total area than upland communities (Swift 1984) and thus play a critical role in maintaining the biotic diversity of a region. For example, about 25% of the birds that occur in the Gila River Valley, Arizona, are restricted to aquatic habitat or riparian vegetation (Hubbard 1977).

Riparian zones have a long history of disturbance by man (Ohmart et al. 1977). Swift (1984) estimated that at least two-thirds of the riparian habitat in the United States has been converted to other land uses and that the loss has been particularly severe in the arid Southwest. In the 1970's about 1,200 ha of riparian vegetation were removed annually from the lower Colorado River (Anderson et al. 1978). A dilemma facing those wishing to create new wetlands from sand and gravel pits in the Southwest is that the likelihood is small that pits located outside of riparian zones and floodplains will have permanent water. Thus the tradeoff between loss of riparian vegetation during the mining operation and the eventual gain of wetlands must be evaluated. We advocate minimal disturbance of existing riparian vegetation, but we assume that under certain circumstances sand and gravel will be extracted from some riparian zones. The following methodology provides potential ways that flooded sand and gravel pits in riparian areas in the Southwest can be managed.

Management Practices

The quality of flooded sand and gravel pits for fish and wildlife is generally enhanced by changing physical and biotic characteristics of the pit during and after the extraction operation so that they approximate specified habitat conditions. The type and extent of such manipulations are bounded by engineering and fiscal constraints. Most recommendations are more easily incorporated when management objectives are clearly defined before the mining begins. Early contact, close cooperation, and free communication between biologists and sand and gravel operators are vital to the success of reclamation plans.

The habitat characteristics incorporated into a pit depend largely on the animals that the wetland is to attract and support. A pit designed primarily to provide foraging habitat for migrating ducks (Bellrose 1976; Brown 1985) might be different from one managed to attract migrating shorebirds (Sanderson 1977) or designed solely to support a warmwater fishery (Bennett 1970). Habitat for a broad array of species, however, could be incorporated into a single pit with careful planning. The reader is referred to Habitat Suitability Index Models (Cole and Smith 1983; Cortese and Groshek 1987) and standard reference guides (e.g., Phillips et al. 1964; Chapman and Feldhamer 1982; Hoffmeister 1986) for syntheses of the habitat requirements of species that might occupy flooded pits.

Fish and Wildlife-related Habitat Features of Gravel Pits

A general overview of the ecology and management of wetlands is provided by Linde (1969) and Weller (1981). We discuss the specific physical and biotic features most amenable to manipulation for creating wetland habitat in flooded gravel pits.

Water Quality

Few water quality problems are associated with ponds created during the extraction of sand and gravel (Herricks 1982). The pH and buffering capa-

Table 1. *Water quality parameters that generally support fish and other aquatic organisms (Herricks 1982).*

Parameter	Range
pH	6.5–9.0
Alkalinity	20 mg/L or greater
Hardness	20–150 mg/L
Dissolved oxygen	5 mg/L, minimum
Dissolved solids (TDS[a])	Productivity generally positively correlated with TDS
Temperature	20–30°C, maximum, depending on species and acclimation

[a]Total dissolved solids.

city of water can be adjusted through application of limestone; addition of agricultural fertilizers may improve production (Bennett 1970; Herricks 1982). Such treatments, however, are often not needed. Water quality will decline if ponds receive heavy agricultural or urban runoff and sediment-laden water. Herricks (1982) offers values within which several water quality characteristic measures ought to fall (Table 1).

Depth of Pit

Gravel mining commonly penetrates the water table and fluctuations in groundwater level will be reflected by pond depths. Pond basins should be deep enough to provide year-round aquatic habitat. If a pit is to support a fishery, the basin must be sufficiently deep to prevent fish mortality from low dissolved oxygen and accumulation of metabolites during summer and winter stratification. About 25% of the basin should be at least 3 to 4 m deep (Bennett 1970).

Shallow-water areas (littoral zone) of less than 2 m deep usually support emergent and submergent aquatic plants that are habitat for aquatic invertebrates (food for fish and wildlife species), for juvenile and adult fish, and for many wildlife species. These shallow productive zones should make up at least 20% of the surface area. Some areas of shoreline should drop rapidly to 1–2 m or more (slope, about 1:2) to help keep some shoreline free of vegetation for shallow open-water species. Crawford and Rossiter (1982) believed that a 50:50 ratio of littoral zone to open water would support the greatest number of wildlife species in North Dakota. A good distribution of vegetation patches can be attained by creating an uneven and rolling bottom where shallow areas (30–50 cm) are mixed with deeper (>3 m) open-water sites. Shallow channels connecting nearby basins increase littoral habitat and permit movement of clarified water from one pond to another (Herricks 1982). Bennett (1970), however, argued against connecting multiple ponds because it makes eradication of undesirable species more difficult.

Water Level Control

Pond and lake management techniques, such as reexcavation of sedimented areas and drawdowns to concentrate predators and prey and to promote shoreline vegetation, are aided by control of inflows and outflows to alter water level. However, such control is difficult to gain in most ponds formed by piercing of the water table.

Shoreline Configuration and Slope

Undulating shorelines with numerous points, coves, and bays provide more land–water edge than straight shorelines (Fig. 1), thereby providing suitable habitat for species associated with shoreline vegetation (Szafoni 1982). Another means of increasing land–water edge is by incorporating islands into the pit design (Fig. 1). Larger islands might support more species than smaller islands (Diamond 1975) but, regardless of size, islands are known to enhance wildlife use of wetlands. Ducks, geese, and colonial nesting birds are especially prone to use islands rather than upland areas as nest sites (Johnson et al. 1978; Landin 1978; Giroux 1981) and often have high nest success in these relatively predator-free areas (Lokemoen et al. 1984). Islands also increase brood-rearing habitat for ducks (Yoakum et al. 1980).

The land around a pit generally should slope gently (1:10–1:20) because neither natural revegetation nor hand plantings are generally successful on steep slopes. Also, some animals will not use sites when the banks are too high. Blomberg (1982) found that use of gravel pits by migrating ducks increased as the ratio of bank height to water surface area decreased. Steep slopes do, however, provide burrow sites for some bank-nesting birds and mammals, such as belted kingfishers (*Ceryle alcyon*), swallows (e.g., *Riparia riparia*), and muskrats (*Ondatra zibethicus*).

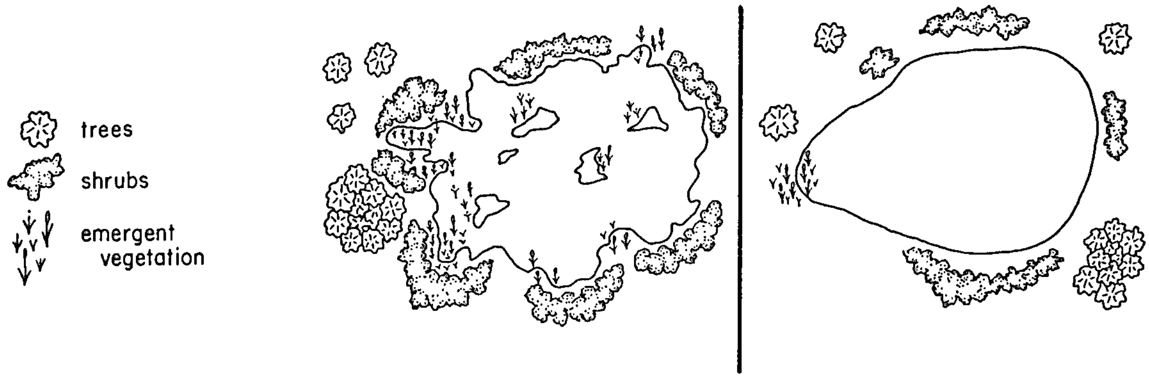

Fig. 1. Undulating shorelines and islands (*left*) provide greater land–water edge than straight shorelines without islands (*right*; after Szafoni 1982).

Size of Pits

It has been difficult to sustain fisheries in water bodies smaller than 0.4 ha (Bennett 1970; Allen and Lopinot 1971), so basins larger than 0.4 ha are recommended. Woodward-Clyde Consultants (1980*b*) suggested that pits be at least 2 ha. The size of flooded pits also influences use by wildlife (Crawford and Rossiter 1982). Migrating and wintering ducks, for example, generally use larger sites more frequently than smaller ones (Hopper 1972; Blomberg 1982). A combination of large and small pits can best meet the habitat requirements of the greatest variety of wildlife species.

Single Isolated Pits Versus Clusters

When several pits are to be placed in the same general area, a question that might arise is whether wildlife habitat requirements are best met by spreading the pits throughout the area or tightly grouping them. Factors not associated with habitat concerns, such as transportation costs and location of deposits, will probably influence (and possibly dictate) the juxtaposition of pits in an area. However, if there is some flexibility in placement, then island biogeographic theory (Diamond 1975) suggests that a tight packing of small wetlands would support the most diverse group of species. The best approach when dealing with questions of this nature, however, is to base decisions on a consideration of the life histories of the most important animals that the wetland is to support.

Basin Substrate and Structure

Many aquatic organisms have specific substrate requirements for reproduction or cover. For example, crayfish either require materials in which to dig burrows or need rocky areas with abundant spaces for shelter. A variety of particle sizes and bottom materials (from sand to large cobbles and small boulders) should be provided throughout the basin, especially along the margins (Herricks 1982).

Attention has been given recently to enhancing habitat for fish and other aquatic organisms by adding structures (e.g., brush and logs, masonry blocks, and used tires joined together). These "artificial reefs" offer cover to fish, and provide clean and firm substrates for growth of algae and aquatic invertebrates (Prince and Maughan 1978; Johnson and Stein 1979; Herricks 1982).

Fish Species Management

Decades of experience with fish populations in small, closed ponds and lakes and reservoirs have never produced the combination of conditions and species that are self-sustaining, and lead to "balanced populations" of desirable-sized fish over a long period (6 or more years), especially with any appreciable angler pressure. Strong biological grounds suggest that it is not possible to do so. Thus, maintenance of a successful sport fishery in small basins not connected to river or large lake systems will require regular manipulation of animal numbers and species, environmental conditions, and angler

activities. Such management is beyond the scope of this review, but is treated in other documents (e.g., Bennett 1970; Anderson 1976; Everhart and Youngs 1981).

Vegetation

Algae and higher aquatic plants (emergent and submergent) are essential features of ponds and lakes, and develop naturally in new basins because of the rapid influx of "volunteer" plants and seeds. In fact, aquatic vegetation has nearly always been overabundant (Hink and Ohmart 1984). Active introduction of macrophytes (e.g., cattails, *Typha*; bulrush, *Scirpus*; pondweed, *Potamogeton*) may speed the development of littoral vegetation, but will generally not be necessary.

Manipulating vegetation to produce desired habitat conditions is perhaps the most effective way of influencing the kinds and numbers of wildlife species that an area will support. General methodologies for seeding, planting, and fertilizing are described by the U.S. Forest Service (1979), and Yoakum et al. (1980). General revegetation techniques for the arid Southwest are discussed by Thames (1977). Specific suggestions regarding revegetation of flooded gravel pits and riparian zones follow.

Two objectives of revegetation on mined lands, applicable to sand and gravel pits, are (1) controlling erosion, and (2) providing food and cover for wildlife species (Morrison 1982). The simplest and most economical way to achieve these objectives is to allow the area to seed naturally. But Morrison (1982) suggested that this approach might not succeed for at least three reasons: (1) erosion could occur before vegetation is naturally established, (2) part or all of the site may not be capable of supporting vegetation without some conditioning, and (3) achieving the desired plant species composition and configuration on areas that can support vegetation is unlikely.

Morrison (1982) and others (Crawford and Rossiter 1982; Sanders et al. 1982) advocate active revegetation programs. Some of their suggestions follow.

- Replace top soil originally removed during excavation to aid plant growth.
- Place hay or other vegetation cuttings on the bottom of pits to help establish detritus food chains.
- Move "muck" from nearby wetlands (if it exists) to the new pit to help establish aquatic plants and animals.
- Select plants for reseeding and transplanting that (1) are compatible with the soil type, moisture conditions, and climate of the area, (2) provide some benefits for wildlife species, (3) are capable of surviving with minimal or no maintenance, and (4) are capable of rapid growth to control erosion, but are unlikely to form dense, persistent stands that retard natural succession.
- Plant a variety of species that have different growth forms in a clumped distribution.
- Leave some of the shoreline and some islands free of vegetation to serve as loafing areas for waterfowl and shorebirds.

Native plants possess most of the characteristics that should be associated with plants to be reseeded and transplanted, and logic dictates that native species be used in reclamation efforts. In practice, however, there has been a greater use of exotic species (Morrison 1982). Arguments against native plants include: (1) seed is not readily available, (2) native species may be more difficult to establish quickly, and (3) productivity of native species may be lower when compared with certain introduced species. In contrast, the major concerns with exotic species are that they (1) can become pest species in the region, (2) sometimes do not provide recognizable sources of food for wildlife species, and (3) may not be able to survive because they are not adapted to the conditions of the area. Use of native or exotic species in revegetation programs should be evaluated on a site-by-site basis, but we urge the use of native species whenever possible.

Anderson et al. (1978) identified habitat components that were important to animal species (primarily birds) in existing riparian communities along the Colorado River and tried to create, by native revegetation (Table 2), riparian habitat in areas that were devoid of vegetation or were covered by the exotic saltcedar (*Tamarix chinensis*). Native plant species such as quailbush (*Atriplex lentiformis*), desert blite (*Suaeda torreyana*), and velvet mesquite (*Prosopis velutina*) that contained mistletoe (*Phoradendron californicum*) were found to be positively associated with abundances of individual bird species (see also Rice et al. 1984), and were used in revegetation efforts. Native plant species found in riparian communities outside of the areas studied by Anderson et al. (1978) are listed by Brown and Lowe (1974), Lacey et al. (1975), and Pase and Layser (1977).

Specific practices that may be helpful when re-

Table 2. *Plant species used in successful revegetation efforts in the riparian zone along the lower Colorado River (Anderson et al. 1978).*

Species name	
Common	Scientific
Blue paloverde[a]	*Cercidium floridum*
Willow	*Salix goodingii*
Fremont cottonwood	*Populus fremontii*
Velvet mesquite[b]	*Prosopis velutina*
Quailbush	*Atriplex lentiformis*
Fourwing saltbush	*Atriplex canescens*

[a]Voluntarily germinated on site.
[b]Planted to obtain mistletoe (*Phoradendron californicum*). Common name follows Little (1979).

planting around newly created gravel pits are

- Assess the chemical (e.g., salt concentration) and physical properties of the site to aid selection of plant species most likely to survive (Anderson et al. 1978).
- Install irrigation systems to provide water for plantings (until they are self-sufficient at about 6 to 12 months of age), and for the growth of annual plant species (Anderson et al. 1978; Schultze and Wilcox 1985).
- For each tree or shrub planted, auger holes to the water table to aid growth. This practice is necessary when planting in compacted desert soils (Anderson et al. 1978; Swenson and Mullins 1985).
- Do not plant trees or shrubs where they will be submerged for long periods (Swenson and Mullins 1985; Schultze and Wilcox 1985).
- Plant trees and shrubs in configurations that provide both horizontal and vertical diversity (Anderson et al. 1978).

After vegetation is established on a site, succession can be kept at the seral stages that best meet the desired habitat conditions by using prescribed fire, herbicides, mechanical destruction of vegetation, flooding, and explosives (Hopper 1972; Yoakum et al. 1980). The method most effective for a particular site depends on the expertise of the people involved, equipment available, and the stages of succession desired.

Special Management Practices for Wildlife

Special methods may be necessary for providing the habitat requirements of some species. Some of these practices are building brush piles for cottontails, quail, and other animals (Shomon et al. 1966; Yoakum et al. 1980); creating or retaining dead trees, or providing nest boxes for hole-nesting birds and mammals (Balda 1975; Scott 1979; Thomas et al. 1979); and creating artificial nest platforms for raptors and some species of waterfowl (Yoakum et al. 1980).

Development of Artificial Backwaters in Floodplains

When mining operations are to occur in riparian areas, opportunities are available for mitigating losses of habitat by creating man-made backwaters similar to natural oxbow lakes or backwater marshes. Natural backwaters generally are highly productive and support a high diversity of fish and wildlife species (Hynes 1970; Welcomme 1979). Modern efforts at constraining river flows to narrow, levied channels have cut off and destroyed many backwaters, and have prevented natural formation of new ones.

There are only a few reports of attempts to create, manage, or enhance man-made backwaters or to evaluate the effectiveness of specific backwater habitat manipulations (Edwards 1982; Schnick et al. 1982; Woodward-Clyde Consultants 1980*a*,*b*). The data most applicable to the desert Southwest are from a series of studies on backwaters of the lower Colorado River (Saiki 1976; Saiki et al. 1976; Kennedy 1979; Kennedy and Tash 1979*a*,*b*). Together, these studies indicate that the longevity, productivity, and habitat quality of man-made backwaters are greatly affected by the amount of protection from main river channel flooding and sedimentation, number and type of connections to the river, flushing rate, and degree of water-level fluctuation.

The greatest danger to man-made backwaters is the ability of rivers to destroy or fill in the basins. Historically, backwaters have been continually created and destroyed as a normal consequence of river dynamics. Ohmart et al. (1975), for example, estimated that natural backwaters of the lower Colorado River had a lifespan of only 50 to 75 years. Thus, if basins must occur in floodplains, they should be located in areas where they will not be inundated regularly nor divert the main channel into the mined area. Edwards (1982) found that lakes on the outside curve of the river channel were virtually impossible to protect from filling. Even those basins on the inside curve required repeated diking at the upstream and riverside margins, with only limited

success over a 20-year period. Thus, the best sites for creating backwaters are on inactive floodplains, terraces, or other areas removed from the main river channel, and have sufficient vegetated buffer or diking to protect them from about a 20-year flood (Woodward-Clyde Consultants 1980*b*).

Studies of backwaters of the Colorado and Mississippi rivers (cited previously) indicate that some interconnections of backwaters and river channels are important. Direct openings to the river (e.g., culverts) permit water exchange that can prevent stagnation and oxygen depletion, renew fresh organic material and nutrients, and allow export of materials such as detritus, plankton, and aquatic invertebrates to the river. Fish are known to readily enter backwaters, especially for spawning, and the free movement of fish into and out of these areas in response to changing conditions is important for maintaining healthy populations. However, if there are numerous uncontrolled connections to the main channel, then high rates of water movement through the backwater will flush out nutrients and preclude development of slow-water habitat features. Numerous openings also contribute to increased water-level fluctuations that are detrimental to aquatic plants and animals. In summary, past research indicates that

- Backwaters should have openings to the river.
- The best openings are gated culverts because they provide control of water flows (see Schnick et al. 1982 for design specifications).
- Openings should minimize excessive flushing and sedimentation but provide inflows sufficient to maintain good water quality, nutrient renewal, and fish passage.
- Backwaters should be separated from rivers by as large a land mass as possible to reduce water-level changes caused by seepage and to protect against floods.
- Backwaters should have areas of maximum depth several feet below the minimum annual water table elevation if severe river drawdowns are likely.
- Openings and side channels may require occasional dredging.

The Fish and Wildlife Service (1978) has identified one other provision for creating backwater habitat in the western States. Where groundwater drains are used to collect and carry away excess irrigation flow, excess rainfall, and groundwater, channels may be shunted through a man-made backwater or marsh where they join a river system. Such techniques have not been studied.

Monitoring

One of the common failings of reclamation projects is the lack of postproject evaluation. A critical examination of reclamation practices is necessary to identify those ideas that worked and those that did not. Such evaluation will contribute greatly to the success of future efforts.

Hink and Ohmart (1984) monitored the short-term effects of a newly constructed pond (borrow pit) in the riparian floodplain of the middle Rio Grande. They concluded that

- Construction of the pond had negative effects on populations of small mammals and many bird species because of clearing of vegetation from the site and increased human use of the area.
- Negative effects would be largely temporary if natural woody vegetation is soon restored in cleared areas.
- The pond created habitat for additional species of birds, amphibians, and reptiles, including some that were normally scarce in the area.
- The new aquatic habitat and associated species should be a long-term benefit, especially if marsh habitat develops in association with the pond.

We believe these results show the type of general response by animals that one can expect when creating ponds in riparian habitat.

Sites that seem to be fully colonized and functioning much like natural wetlands may be drastically set back by natural or man-caused events. Selected critical biotic and environmental conditions (e.g., size and depth of pit, amount of open-water habitat, number and type of plant and animal species, incidence and area of habitat loss or degradation) should be periodically monitored (every 3 to 5 years, depending on the type of measure) to determine continued functional integrity of the biotic system and its associated benefits. Long-term monitoring is especially appropriate when fish and wildlife habitat has been enhanced as mitigation for long-term or irretrievable losses of natural habitat.

Summary

Site Selection

Sand and gravel removal should be avoided within riparian zones because riparian areas are of high ecologic, economic, and aesthetic value and are

becoming increasingly rare, especially in the Southwest.

If some riparian areas must be disturbed, preplanning and management for disturbed sites and protection of adjacent natural sites can enhance fish and wildlife habitat of the area and contribute to mitigation of unavoidable losses of habitat.

Pits must be sufficiently distant from the active river channel (or protected by diking) to avoid diversion of the main flow through the mined area or rapid filling by sedimentation from repeated inundation. Pits that have at least one connection to the river may act like natural backwaters and permit highly productive interchanges to occur between the river and the backwater.

Management Recommendations for Enhancing Fish and Wildlife Habitat

Management for best combination of physical and biological characteristics can only be determined with respect to the species expected or desired to use the area. General recommendations follow.

- A premining plan for postmining habitat goals will permit mining activities to create the initial stages for final conditions.
- Pits must be excavated to a depth that provides continuous aquatic habitat (at least 3 m) but shallow enough in some areas to support emergent and submergent aquatic plants.
- Undulating or irregular shorelines and islands are desirable to create land–water edge and a variety of habitat conditions.
- A combination of large and small pits may support the widest variety of fish and wildlife species (minimum basin size is 1 to 2 ha).
- Seeding with wetland muck can speed development of aquatic plants and invertebrates.
- Revegetation of disturbed areas surrounding a pit should control erosion and provide food and cover for wildlife species.
- Revegetation can be accelerated and made more successful when topsoil is returned to mined areas, plant species are compatible with the soil and climate, irrigation provides water until plantings are self-sufficient, auger holes to the water table are provided for trees and shrubs planted in compacted desert soils, trees and shrubs are not planted where they will be submerged for long periods, and a variety of trees and shrubs are planted to provide both horizontal and vertical diversity.
- Native plant species should be used whenever possible.
- Special habitat management (e.g., building brush piles, nest boxes, nest platforms, and artificial reefs) may be necessary to attract and retain some fish and wildlife species.

Considerations During Mining

- Minimize equipment and vehicular access through vegetated floodplains.
- Floodplain access should occur at the inside of a meander to avoid incising banks at outside meanders.
- When a bank crossing is required, it should be protected with a gravel fill ramp.
- Avoid crossing active channels.

Monitoring

Monitoring the status of selected conditions over the first 1 to 2 years after habitat construction is necessary to determine the efficacy of management manipulations for creating fish and wildlife habitat of high quality (as outlined in a reclamation plan). Unsuccessful efforts, once identified, can be replaced by more appropriate approaches. Periodic (every 3 to 5 years) monitoring of selected critical conditions (e.g., size and depth of pit, amount of open-water habitat and type of major plant and animal species, incidence and area of habitat loss or degradation) should be monitored to assure that habitat, once established, is not lost.

Acknowledgments

This study was conducted under the auspices of the Arizona Cooperative Wildlife Research Unit: University of Arizona, Arizona Game and Fish Department, U.S. Fish and Wildlife Service, and the Wildlife Management Institute cooperating.

This review was requested by the Director and staff of U.S. Fish and Wildlife Service Region 2, Albuquerque, New Mexico, and was developed in cooperation with the Service's Research and Development Office of Information Transfer, Fort Collins, Colorado. Albuquerque Regional Office personnel and staff of Ecological Services Offices in Phoenix and Albuquerque provided review of drafts of the document as did Ronald E. Kirby of the Office of Information Transfer, project officer for the work. Funding for this synthesis and for publication was

provided by the Cooperative Research Units Center, Washington, DC.

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Mining of sand and gravel can disturb valuable riparian habitat in the Southwest. Reclaimed lands provide fish and wildlife habitat if water is present. The shape, location, and number of pits, and the type of revegetation affect colonization by animals. Sand and gravel pits can be restored for wildlife use but monitoring is necessary to evaluate the efficacy of reclamation.

Key words: Mining, sand, gravel, reclamation, habitat, riparian areas, pits, wetlands, Southwest.

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☆ U.S. Government Printing Office: 1988—572-205/80010

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